THE ANATOMY AND LIFE HISTORY OF THE TREMATODE, CYCLOCOELUM JAENSCHI N. SP.

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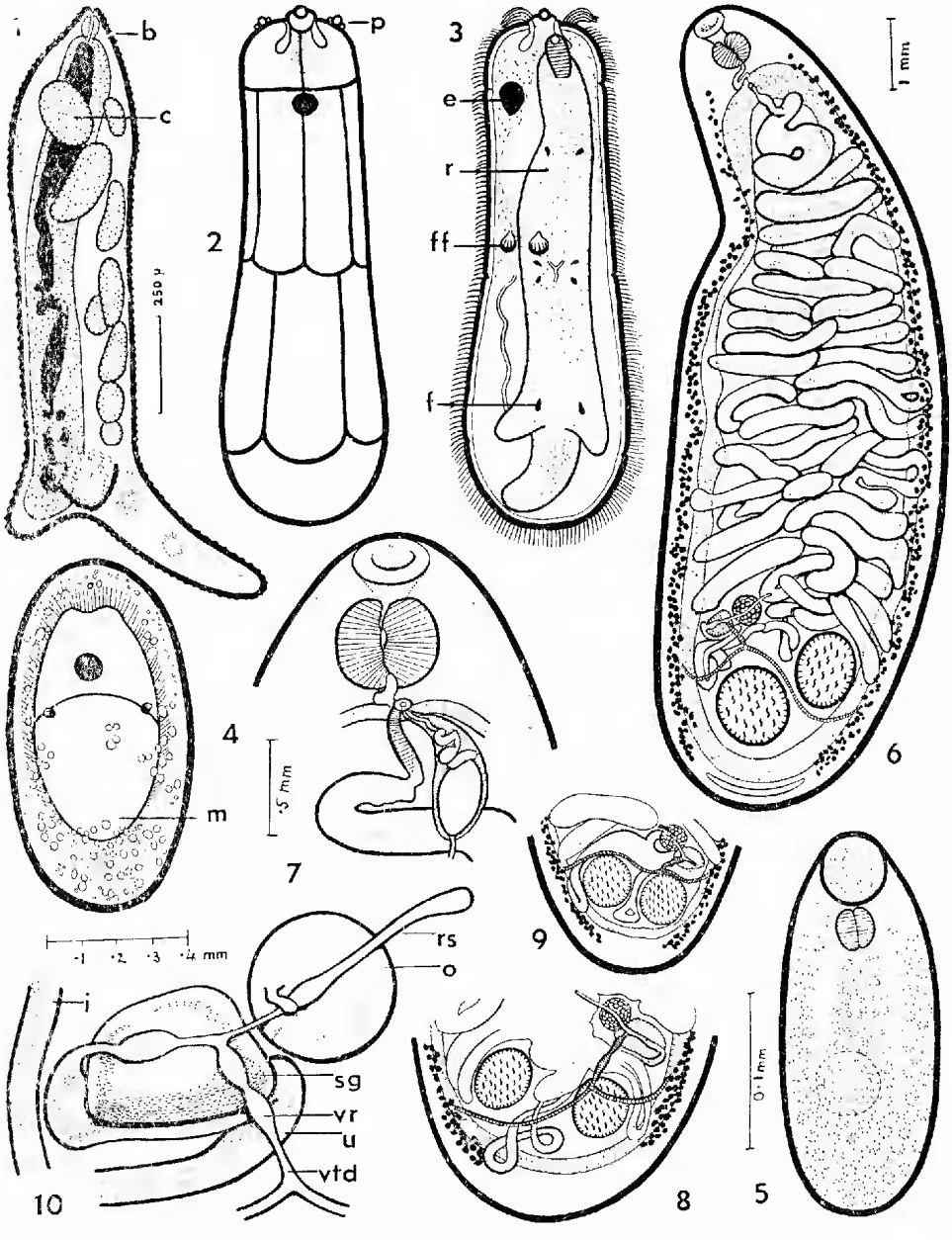
Adults of **Cyclocoelum jaenschi** n. sp. were found during 1937 in the abdominal air sacs of two species of small grebes, *Podiceps poliocephalus* Jardine and Selby, and *P. novaehollandiae* Stephens *(P. ruficollis novaehollandiae)*, taken by Messrs. G. and F. Jaensch at Tailem Bend, Lower Murray River. The parasites measured from 7 to 9 mm. long by 2·3 to 3 mm. broad. The succeeding measurements were taken from a mounted specimen which had been compressed, its dimensions then being 11 mm. in length and 3·7 mm. in maximum width, with the anterior fourth narrower and with both ends broadly rounded. The oral sucker was nearly as wide as the pharynx (0·5 mm.). The narrow oesophagus was thrown into one or two curves partly above the genital apertures. The rather narrow intestinal crura had an uneven lumen, somewhat wider in their most anterior part and in the posterior quarter. The excretory bladder was transversely elongate, lying just behind the united crura, its pore being dorsal and practically terminal. The well-developed lymph system consisted of a great number of flattened anastomosing canals, some wide, others narrow, above and below the crura, with branches extending laterally from the latter as well as into the intercrural region, and in addition anteriorly, beside the pharynx and anterior sucker. The details were not worked out. Willey (1935) gave an account of the system in Cyclocoelidae. The testes were subequal, the posterior 1 mm. and the anterior ·9 mm. in diameter. The cirrus sac was slightly oblique, just behind and partly below the intestine. Entering its posterior end was a very narrow, thin-walled vas deferens, which then widened into a large elliptical seminal vesicle, ·45 by ·25 mm., followed by the narrow twisted (when resting) male duct. The male pore, together with the much wider uterine aperture, was surrounded by a mass of sphincter fibres. The genital openings were directly below the oesophagus in the posterior half of its length.

The small rounded ovary, about 0·4 mm. in diameter, was just in front of the level of the anterior testis and separated from the latter by uterine coils. The very short oviduct arose dorsally from its outer region. Lying postero-laterally from the ovary and in contact with it was the shell gland, which was slightly wider. The yolk follicles extended from a point just behind the level of the base of the pharynx to the corners of the excretory bladder, and lay ventrally and laterally from the crura, overlying part of the latter in some places. The main duct on each side passed backwards below the intestine. The transverse yolk duct of one side travelled inwards behind the anterior testis and then forwards



Figs. 1-10

Fig. 1, mature redia; 2, miracidium, showing epithelial cells, etc.; 3, miracidium with redia; 4, egg, with miracidium; 5, cercariaeum; 6, adult; 7, anterior end; 8, 9, variations in position of genital organs and ducts; 10, female system.

Figs. 2-5 drawn to scale beside fig. 5.

Lettering—b, birthpore; c, cercariaeum; e, eye; f, flame cell of redia; ff, flame cell of miracidium; i, intestine; m, miracidium; o, ovary; p, papilla; r, redia; rs, receptaculum seminis; sg, shell gland; u, uterus; vr, vitelline reservoir; vtd, vitelline duct.

in the intertesticular zone to meet its fellow which passed inwards in front of the posterior testis. In front of the latter, the short common yolk duct curved upwards and forwards to pass above the uterus and shell gland, becoming swollen to form two vitelline reservoirs and then meeting the fertilising canal lying at right angles to it. This latter extended inwardly above the ovary to receive the oviduct and then continued, ending blindly as a seminal receptacle a little distance from the midline of the worm. The ootyp travelled outwards through the shallow shell gland, and on leaving it, widened considerably, then curved ventrally between the shell gland and the intestine and bent inwards below the former to reach the border of the ovary. It then curved outwardly under the common yolk duct to become thrown into several loops in the region between the shell gland, the posterior testis and the intestine, penetrating to a varying distance between the two latter. The uterine coils then crossed into the zone between the ovary and the anterior testis and usually, between both testes, to reach the intestine. The rest of the uterus constituted a fairly uniform tube, greatly looped and occupying all the intercrural region in front of the testes (except the zone occupied by the ovary and shell gland). In the posterior half of the worm, many of the loops extended laterally above the crura into the vitelline zone. Just behind the intestinal bifurcation the duct dipped downwards and forwards, rapidly narrowing to terminate at the female aperture adjacent to the male pore. The terminal part of the uterus was well provided with circular muscle fibres. Eggs were amber-coloured, elliptical, 195 by 94 μ, with an operculum with a serrated edge. The eggs in the anterior half of the uterus contained each a miracidium with a conspicuous eye-spot, as well as a redia.

In specimens subjected only to cover-glass pressure the posterior testis measured 0·5 to ·6 mm., the anterior testis ·45 to·52 mm., and the ovary ·2 to ·3 mm. in diameter; the cirrus sac ·8 to 1 mm. long and ·28 to ·35 mm. in maximum width; the oral sucker ·4 to ·45 mm. broad; and the pharynx ·5 mm. long by ·55 mm. broad.

Variations were observed in the positions of the testes, uterine loops, and transverse yolk ducts as well as in the extent of the vitelline glands. The testes were sometimes almost symmetrically placed. Sometimes the earlier uterine loops extended backwardly only as far as the most anterior part of the posterior testis; but in other cases the extension almost surrounded the latter, the uterus extending through the intertesticular to meet the intestine. The uterus also invaded, to a greater or less extent, the zone between the anterior testis and the intestine. Sometimes the anterior limit of the yolk glands did not reach as far as the base of the cirrus sac, and in several cases the extension was different on the two sides of the worm. The usual disposition of the transverse yolk ducts was that described above, but in one instance they both lay in front of the two testes; while in another case one travelled behind the displaced anterior testis and the other crossed the posterior testis to join its fellow above the latter.

The species is named in acknowledgment of the generous assistance given us for some years past by Messrs. George and Fred. Jaensch of Tailem Bend. The type, a mounted specimen from *Podiceps novaehollandiae,* has been deposited in the South Australian Museum, Adelaide. Our investigation has been assisted by the Commonwealth Research Grant to the University of Adelaide. The arrangement of the testes and ovary and their relation to each other, the position of the genital pore in relation to the pharynx and oesophagus, the disposition of the uterine loops in relation to the testes and the intestine, as well as the disposition of the vitellaria, serve to differentiate *C. jaenschi* from all other described species of the genus. The organisation of the region adjacent to the genital apertures closely resembles that indicated in Harrah's figure of the similar region in *C. elongatum.*

Our species shows characters belonging to the two tribes Haematotrephea and Cyclocoela as diagnosed by Witenberg, more particularly the former in regard to the arrangement of the gonads. Some of our specimens would fall into his genus *Corpopyrum,* but the others could not be accommodated in *Cyclocoelum* in the restricted sense in which Witenberg proposed to restrict it. Those specimens which would fall into *Corpopyrum* resemble *Cyclocoelum tringae* (Stossich), *C. brasilianum* (Stossich), *C. wilsoni* Harrah, and, in some features, *C. halli* Harrah, but they differ from these species as figured by Kossack (1911), Harrah (1922), and Witenberg (1926) in some of the features mentioned above. It seems to us preferable, in view of our observations regarding variations in organography, to suppress *Corpopyrum* as a synonym of *Cyclocoelum,* as Joyeux and Baer (1927) have already suggested, and to use the older conception of the latter. Witenberg's subgenus *Antepharyngeum* must also be suppressed as it includes *C. mutabile,* generally regarded as the type of *Cyclocoelum.*

Life History

The eggs hatched in tap water within a few hours. The miracidium bears long cilia, especially elongate on a collar surrounding the head lobe, but absent from the latter and also from the boundary lines of the epithelial cells. These cells were arranged in four rows; their number was not ascertained, but there were probably 15 to 20. Two small glands, one on each side, open at the base of the protrusible head lobe and pour out their secretion immediately prior to the extension of the lobe. Just in front of the ciliate collar there are, on each side, a large and two small papillae. The miracidium was phototropic, with a large eyespot situated near the junction of the first and second rows of epithelial cells. Two large flame cells were observed near the centre of the body, but only one excretory tube was seen continuing posteriorly. Lying free in the cavity of the mature miracidium is a relatively large active redia with a well-developed pharynx and two ambulatory processes, as well as four pairs of flame cells, two anterior and two posterior. These flame cells, together with the main excretory tubule and its two branches, were seen near the midregion of the larva.

Eggs obtained in December 1937 hatched next day and were placed in contact with pond snails, *Planorbis isingi, Limnaea lessoni* and *Ameria pyramidata*. About three weeks later several specimens of the first-named were dissected, but larval trematodes were absent. The *Limnaea* snails died within a few days, and examination failed to reveal any stages of the parasite. One specimen of *A. pyramidata* died thirty-eight days after contact and was found to contain four large rediae near the albumen gland and numerous cercariaea lying free in the adjacent tissues. A week later an *Ameria* was dissected and three large rediae were found near the head, the largest being 1·65 mm. by ·50 mm., and the smallest ·96 by ·21 mm. The largest may have been a mother redia and the others daughter rediae, unless multiple infection had occurred and one of the larvae had become located in a more favourable situation than the others. The latter view is the more probable, since Szidat (1932) and Stunkard (1934) did not observe a second generation of rediae in allied monostomes. The redia figured by us (fig. 1) was obtained from a dead *Ameria* and measured 1·75 by 0·3 mm. It contained developing germ balls and cercariaea and possessed a tail-piece and two well-marked ambulatory processes in its posterior third. The birthpore lay near the mouth. The pharynx measured 44 μ long by 40 μ broad. The long intestine contained dark brown material and, when the redia was placed in water, the organ was observed to contract and, on relaxation, might pass back into one of the foot processes or into the tail piece. The body covering possessed an irregular network of cuticular ridges or papillae, so that a spiny appearance was presented in side view.

Tail-less cercariaea were very thin and transparent, measured (average of five preserved specimens) ·225 mm. long by ·116 mm. broad. They lived only a few minutes in water. The anterior sucker and the pharynx were about 40 μ and 20 μ in diameter respectively. The intestine was largely obscured by the abundant cystogenous glands. A very weak posterior sucker lay in the posterior half of the worm. A number of cysts, apparently belonging to the species, occurred in the snail's tissues.

Our observations appear to be the first published relating to the life cycle of a species of *Cyclocoelum*. Szidat (1932) indicated that Siebold in 1835 and Wagner in 1858 had reported the occurrence of a bud (*i.e.*, a redia) in the miracidium of *Monostomum mutabile* Zeder and *M. flavum* Mehlis. These worms are *Cyclocoelum mutabile* and *Typhlocoelum cucumerinum* (Rud.) respectively. Szidat (1932) gave a detailed account of the life cycle of *Tracheophilus sisowi* Skrj., a parasite of East Prussian ducks, the intermediate host being a species of *Planorbis*. He drew attention to the presence of a ventral sucker in the cercariaeum in the gastropod and in the wandering metacercaria from the lung tissues of the duck. Stunkard (1934) gave an account of the life history of *Typhlocoelum cymbium* (Dies.) from a grebe, *Podilymbus podiceps*, the intermediate host being *Helisoma trivolvis* in North America. *Tracheophilus sisowi*

was considered to be a synonym. Stunkard fed a few cysts to a domestic duck but did not obtain later stages.

The life cycle seems to be similar in *Cyclocoelum, Tracheophilus* and *Typhlocoelum.* We have observed that the egg of *Haematotrephus adelphus* S. J. Johnston, whilst still in the uterus, contains a miracidium enclosing a well-developed redia essentially similar to that described above. It seems to us likely that all members of the Cyclocoelidae have a life history as follows: the egg, before laying, contains a miracidium within which is a redia; the egg hatches soon after access to water; some species of freshwater pulmonate gastropod acts as intermediate host; there is neither sporocyst nor secondary redia stage; the cercaria is tail-less and encysts within the host in which it has developed; the final stage is reached when the appropriate species of bird eats the infected mollusc; all the cercariaea have ventral suckers.

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